The scientific basis for the reconstruction of prehistoric and protohistoric houses

The purpose of this paper was to explore the scientific basis of building reconstructions. The critical issue was to address the problems of reconstruction in order to specify limits within which the reconstruction is of research/educational value and to a set standards which may act as guidelines.

† Peter J. REYNOLDS
Butser Ancient Farm (UK)

In 1966 just outside the boundary of a hill fort known as Kemerton Camp on top of Bredon Hill (*Hencken 1939*) in Worcestershire a small roundhouse was reconstructed, based upon the excavations carried out at Glastonbury Lake Village some fifty years before (*Reynolds 1967a, Bullied and Grey 1911*). A group of students under the guidance of Mr. Philip Barker of Birmingham University, carrying out a routine site visit, were deeply impressed to come across the three dimensional reality of something which had been previously discussed **in vacuo**. In effect the house reconstruction was an element of a small integrated research programme examining the domestic and agricultural economy of the Iron Age (*Reynolds 1967b, 1969*). The purpose of the house reconstruction was entirely oriented towards a research mode and fundamental questions involving material requirements, the effects of the environment upon the structure and the effects of the structure upon its immediate environment. In the event the reconstruction lasted but a short period before it was burned down by vandals and consequently only indications of the potential of reconstructions were realised at that time. This episode, nonetheless, focuses exactly upon the dichotomy of motivations for reconstruction. On the one hand there is the research motivation which includes questions of material resources, their management, the engineering necessities of construction, environmental observations, functional analysis, structural degradation through time and critically the physical interpretation of archaeological trace evidence. On the other hand there is the educational motivation which must include both museological and entertainment elements. The research mode clearly contains a major educational museological input in that a three dimensional structure is an overt demonstration which can be utilised in a great number of ways that need not conflict with basic research parameters. However, during the last twenty years, with a marked acceleration in the last five years,[1] there have been built a large number of reconstructions throughout Europe which are inspired not by any altruistic educational or research motive, but rather a thinly disguised commercial venality. To a great extent these reconstructions are to be found in theme parks and leisure complexes designed to mimic the Disneyworld Enterprises in the United States of America. Such theme parks, a permanent successor to the travelling fair,[2] are designed to entertain the public on a purely commercial basis. It is to be regretted that so many of the historic and prehistoric elements have been created, often at great expense, without any recourse to professional advice. Had sufficient research been carried out by the designers a better end product could well have resulted, at far less cost and to the mutual advantage of all parties, not least the public who are most at risk. Educationally, simply because of the understandable popularity of the ‚modern fairground', the result is quite disastrous. Prejudice and ignorance are reinforced across a far greater percentage of the population by default. Unfortunately the theme park approach has inspired a number of smaller enterprises, similarly motivated by commercial reasoning, to ‚recreate' periods of the past with ‚appropriate structures' and most unhappily with ‚actors' dressed for the part.

While this is undoubtedly the case, the question of responsibility necessarily arises. A proportion of that responsibility, probably the greater part, must be shouldered by the academic community. Reconstructions motivated by research intentions have been part of European thinking for several decades. Scale models through one-to-one structures to complexes of structures can be found in virtually every country. That the exploitation of this approach has subsequently been left to entrepreneurial business can hardly be a charge raised against the exploiters. Rather it is a further representative facet of the malaise of archaeology, then being a basic lack of communication skills. This is not to impugn the process of academic publication or to encourage popularisation at the cost of integrity. It stresses rather an inability to communicate with the public at an appropriate level and thereafter to exploit the undoubted general interest of the public to the advantage of archaeology as a whole. That the public interest exists is abundantly proven by the elements contained within theme parks and their like, an interest which can arguably be identified as the 'heritage syndrome'. Recently some attempts have been made to rectify this situation, most notably at the Jorvik Viking Centre in York where excavation and reconstruction are presented in dramatic style employing Disneyworld techniques to the best advantage. Its success and popularity are undeniable, its realisation of marriage of investment venture capital and archaeological expertise on a sound business footing. Yet even this enterprise denies the presence of any research element. Rather it is the explanation of an excavation, the interpretations frozen at a moment of time allowing for little or no development.

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The critical issue is therefore to address the problems of reconstruction in order to specify the limits within which reconstruction may be welcomed and to set out standards which may act as an advisory remit. It is only by setting out clearly and authoritatively levels of acceptability against which any product may be measured that the issue may gain any resolution. The purpose of this paper is therefore to explore the scientific basis of reconstruction and attempt to isolate the pertinent ranges of questions which will not only allow but foster as many variants as possible. To achieve this end a number of case studies including a detailed report and analysis of one major reconstruction have been used. All the examples quoted have been the direct responsibility of the author and to an extent demonstrate the learning process. In any received body of information there has to be evidence of progression primarily in the exploration of the original concept which argued for reconstruction in the first place.

Before approaching any reconstruction it is important to resolve a number of arguments which are inherent in archaeological methodology. Of these perhaps the paramount one is philosophical, concerning the data recovered by excavation. The basic premise must be that the data inspire the interpretation. An interpretation which does not agree with the data is entirely unsatisfactory although it may, in fact, prove to be correct. In effect this latter approach has gained considerable popularity in recent years where ephemeral and postulated data have been employed to construct models of social organisation and even kinship (*Clarke 1978; Hodder, Isaac and Hammond 1981; Kimes, Haselgrove and Hodder 1982; Renfrew and Shennan 1982*). Essentially the data are the hard evidence, particularly with reference to a structure. While it may be possible, once a sufficiently large database has been acquired, to reinstate ‚missing' elements that database is currently not available. Therefore, a reconstruction virtually by definition must be specific to a set of excavated data. A generalised reconstruction thus relies particularly on a synthesis of data from disparate sources and serves only to underpin prejudices. Inferred hypotheses do not necessarily advance our comprehension of the actual problems.

Similarly reconstructions, to have any value, must be at a one-to-one scale with the original evidence. Scaled models particularly of wooden structures representing vernacular architecture are largely unsatisfactory from any standpoint. The nature of timber, especially in the round, its weight, its size to strength ratios denies miniaturisation for any empirical purpose.(3) Even in terms of museological representation such models are unsatisfactory since the buildings concerned are directly relative to human experience. Even from the simple visual aspect such models are doomed to be only models. Given the modern skills of architectural modelling with contemporary materials of concrete, brick and steel, for which there is a full mathematical and engineering data base, these museological representations of pre- and protohistoric structures are put into an even more inadequate context.

Empirical trials with models like those carried out by Sarayader (*1983*) with Amerindian structures seeking to establish ‚comfort levels', similarly beg the question of an adequate comprehension of materials and their interaction both with each other and with the environment. Any reconstruction of a building can only be justified if it is firmly keyed into the archaeological process. In practical terms an excavation which reveals the original presence of a building, particularly in ‚dry' archaeology, provides evidence of the final state of that building. A pattern of postholes and stake-holes, disturbances, hollows, trenches and the like which is recognised by the excavator as the evidence for a building but needs to be appreciated as the ‚death' state, a state which not only provides an original plan but which also provides evidence of the life span. Repairs, extensions, alterations, refurbishments are all part of the life of a structure. The distinction between the original building plan and subsequent structural changes which include repairs is critically important. Even in the original building plan it is important to isolate, if possible, constructional and structural elements. In effect a reconstruction can only be archaeologically justified if it feeds back into the excavation positive and negative data about the structure. Ideally, since a reconstruction creates an hypothetical new building, the birth state of the archaeological evidence, further empirical trials are needed to monitor its life span both as a structure in terms of its requirements as a structure, repair and refurbishment for example, and its function and the traces that function might create. In this particular connection function can be further subdivided into the human activity for which the structure was designed and the effect the structure had upon its immediate environment in terms of identification by geophysical means. With recent advances in geophysical prospection, particularly the magnetic susceptibility of the soil (*Clark 1990*) there is a clear case for monitoring within and without the structure. Recent research indicates that a structure has an irreversible effect upon the ground surface it covers (*Reynolds 1995*). Similarly if a structure is given an hypothesised function by the excavator, the replication of that function empirically may well provide confirmatory evidence. The clearest example is the permanent or seasonal housing of livestock and the ensuing enhanced phosphate levels identifiable in the subsoil (*Pryor 1980; Reynolds 1995*). Naturally this approach is significantly useful since, once an association of cause and effect with attendant intensity levels has been established, the scientific analysis of site evidence may be used to provide evidence of function where visually none exists. In other words, the creation of a proven data base will enhance archaeological interpretation without any further necessity for reconstruction.

The ultimate phase in reconstruction has to be, logically, viewed as destruction. It is only at this point that a real correlation can be made with the original evidence upon which the reconstruction was created. The most dramatic and statistically least normal end of any structure has to be conflagration; a trial carried out but as yet not fully published by Hansen. Probably the most useful data would be forthcoming from abandonment following a period of use. Such a trial, however, is only possible should a reconstruction be adjudged to be sufficiently accurate. This ultimate phase, however, begs the real question of the validity of function.

In recent years there has been an emphasis upon ‚reliving the past'.

On one occasion a group of people, suborned by television, attempted to live an Iron Age way of life for a year (*Percival 1979*). The outcome proved to be a strange style of ‚soap opera', perhaps satisfactory to a viewing audience but of no real value to archaeology whatsoever. It is the convinced opinion of the writer that mankind is locked into his own time, the only escape being into the future. This does not deny the indulgence and entertainment of re-enactment, nor the potential educational value that it may have. Rather it points to the impossibility of recreating ‚Everyday Life' of any period in the past. Anthropology serves to underline the immediate impact of interactive presence in remote communities. The more so for individuals from a modern society playing at being prehistoric man. Therefore any study of the function of a structure has to be virtually dehumanised and limited to choiceless action. Within this constraint the area of study is inevitably much reduced to activities like traffic wear or erosion through doorways and the effects of domestic fires and cooking areas in terms of wood supplies. On the other hand functions involving livestock, particularly seasonal indoor maintenance, is perfectly viable as is the examination of specific agricultural and industrial processes and functions. One example of a dehumanised empirical function has been the examination of the so-called Romano-British grain drier referred to below (*Reynolds and Langley 1979*).

Consequently a realistic total testing of a reconstruction, except in very particular circumstances, from building through function, degradation and destruction, may be impossible not least from the point of view of the life expectancy of a structure which may reasonably be expected to extend over many decades if not centuries. On the other hand much may be learned, up to and partially including human activity, of the life span of a structure. Certainly the balance is in favour of reconstruction in that the data base can only be enhanced.

The ideal approach outlined above presents a full cycle for a reconstruction, as in any ideal it is an extreme case. There is no doubt that the learning curve is strongest at the initial construction stage, the yield of information levelling off significantly after completion and becoming increasingly less after approximately fifteen years. Since this is the case, reconstruction can be categorised to include those designed for museum purposes, educational motives as well as components of integrated long-term research programmes. There is no reason whatsoever why any reconstruction should not be a part of the excavation/interpretation process initially, and thereafter fulfil alternative requirements. However, this will only happen if the reconstruction is site specific and is motivated by the requirement for answers from questions raised by the excavated data. This approach is the more desirable because of the not inconsiderable costs involved and the need to maximise a return from the investment. Further there is a clear element of responsibility to the public at large who invariably, directly or indirectly, provide the funding both for excavation and interpretation. A generalised reconstruction without any scientific basis is no more than a simple insult. Particularly marked are the occasions when the public includes building engineers, architects and craftsmen, all of whom are probably better qualified to assess the building in question rather than the archaeologist who is straying beyond his brief. Loss of professional credibility can be damaging especially when caused by elementary errors, the most common of which is found not so much in physical reconstruction but rather in reconstruction drawings. Regularly a splendid archaeological report of an excavation is marred by a drawing of a structure which would defy physical realisation. Such ‚paper tigers' are to be avoided. Indeed, this aspect alone must be adequate justification for reconstruction.

Structural reconstruction can quite properly be part of a museum complex within the context of empiricism but with a specific **caveat**. Should the reconstruction prove to be in error in part or whole, the error should be recorded and corrected, even if this means a total rebuilding of the structure. The use of modern materials, the ubiquitous long steel nail, to fudge constructional detail is of no advantage whatsoever. The subsequent maintenance of the structure, however, since the data yield from the construction is one of the greatest sections of the learning curve, can be thoroughly modern and recognised to be so because the experiment is effectively concluded and all that is required is exhibition. The same is true for educational programmes and, indeed, for theme and leisure parks referred to above. At least the end product has satisfied the basic criteria of springing from and therefore elucidating the archaeological evidence.

Finally one overriding problem besets all reconstruction work. Can the time taken to build a structure have any significant value for the understanding of prehistoric or historic labour input? The supplementary question concerns the tools with which a structure is made. Should such tools be replicas of the originals? To both principal and supplementary questions the answer has to be a firm negative. The main question of time taken to construct a building, especially since the process is essentially one of trial and error, is entirely superfluous. Even if one became skilled in the construction techniques, comparable to a qualified modern bricklayer, the question is still meaningless since the motivation is unknown. The analogy of the modern bricklayer holds good in that, depending upon pay return, two hundred or a thousand bricks can be laid in a day. With regard to tools, the answer can be found by refining the question. The object of study is the building itself and given the irrelevance of the labour input, modern equivalents to the original tools are sensible and adequate. The study of ancient tools is specific to the tools themselves in that one's major interest is the effect of the work on a replicated tool. Tool manipulation immediately encroaches upon skill and labour input associated with time expenditure.

The following case studies are drawn from the experience of the writer and are used here to substantiate the elements of the argument presented above. No account has been taken of other reconstructions, since the nature of the workshop[4] is to bring together interested parties from all over Europe who will present their own material evidence. With some exceptions a major emphasis is placed upon the author's research of structures of the British Iron Age. Detailed analyses are not given for the majority of the cases discussed, only those observations which are relevant to the discussion.

The insular building tradition of Iron Age Britain differs from that of the continent, with the exception of northwest Spain, in that the normal house was circular in plan. Thus the problems experienced in reconstruction are quite different from those of a rectangular structure. In simple terms a roundhouse comprises a cylinder surmounted by a cone. In building, one is continually exploiting the principle of the tripod rather than the ‚A' frame and using balanced opposing forces in a three dimensional field. In all cases a round house gains strength steadily throughout the construction period, being strongest only at completion. In effect a roundhouse can be built of slight materials and still achieve remarkable strength. In contrast a rectangular structure is created with the in-built strength of each component element. Ultimately the roundhouse presents the perfect structure since aerodynamically it offers the least resistance. This factor contributes significantly to its life expectancy.

Case Studies

Each structure referred to below is allocated the site name from which the evidence came.

Maiden Castle House (Wheeler 1943)

The plan for this reconstruction was drawn from the excavations of Maiden Castle in Dorset. Specifically the plan for Hut Db was used as the basis for this reconstruction, the first to be built at the Butser Ancient Farm Research Project on Little Butser (*Reynolds 1978*). Essentially the plan comprised a circle of postholes with a centrally placed posthole. It was decided to build this structure using the simplest technology, the only joints being the mortice and tenon joints joining the lintel to the door posts. The walls were interwoven with hazel rods creating a very strong basketry frame, the full cylinder being completed with the lintel span across the doorway. In all such reconstructions of simple as opposed to complex roundhouses it is necessary to prop the doorposts to counteract the outward thrust of the basketry walls. A central post with a Y fork was set into the centre of the floor to support the roof apex, the angle of the roof being at the critical functional angle of 45° to the horizontal. At angles of less then 45° and more than 55° thatched roofs leak (see below Balksbury House). The initial tripod of rafters were laid into the Y fork and lashed to the side of the wall uprights with rawhide thongs. A supplementary ring was attached to the tripod one third down the slant height of the rafters and to it were attached the remaining rafters, the ends of which were similarly lashed to the sides of the uprights in the wall. The house was completed with the application of daub to the walls inside and out and the roof was thatched with straw. A door of split oak planks was fitted to the doorframe with pivot hinges set in the lintel and a sill set on the ground surface.

For a period of ten years this structure fulfilled all expectations. It successfully withstood extremes of weather including tornado force winds, heavy snowfalls and torrential rain. After this time, however, the rawhide lashings began to fail and the roof began to move downward roughly at a rate of 50 mm per annum. Gradually the wall posts began to protrude through the roof, the brittle wall cladding giving way under the weight thrust. As the roof descended the central support post caused the rafters to pull inwards at the wall circumference in a similar behaviour pattern to an umbrella closing. Finally the roof twisted through approximately 15° causing partial wall collapse with the original tripod held in place by the central support erupting through the apex of the thatch. In all senses the structure failed.

The object lesson from this reconstruction underlines the critical requirement to study a building through time. Fundamental building errors will not necessarily become immediately apparent. In this case the building gained ready acceptance as a reasoned projection of the archaeological evidence only to fail subsequently. Two structural elements were in error. The rafters must be set upon the top of the wall posts probably with a simple notch, and secondly the central support pole is totally unnecessary to the structure. In all probability an alternative interpretation for this feature should be proposed where it will fulfil a non-structural role.

■ **Fig. 1** Maiden Castle house: the completed structure. Set on the exposed spur of Little Butser this house has withstood hurricane force winds with impunity. Aerodynamically its shape is ideal At no time is a flat surface presented against the elements (in: Reynolds 1979, 35).

One interesting ancillary result emerged from this structure during its life span. The space under the wall was exploited by rats and mice. They effectively tunnelled around a third of the circumference of the building at a depth below the base of the posts of the wall thus obliterating the post-hole evidence. In archaeological terms the house was part gully, part an arc of post-holes.

The further observation this house allowed for was the effect of water run-off from the roof. Expectation argued for the gradual appearance of a drip gully. In fact, the opposite condition occurred. Directly beneath the eaves a protected habitat was created where plants flourished undamaged by the passage of feet. Through time, even though these plants, primarily nettles, weeds and grasses, were trimmed back, a ridge of humus was formed. Between it and the house wall because of the lack of light, and therefore an absence of photosynthesis, shallow erosion occurred to a depth of 100 mm. Finally the threshold of the house became considerably eroded due to passage of feet especially in wet weather leading to a

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sizeable puddle being created. This particular observation allowed the author to identify the presence of doorways at an excavation of a group of Iron Age roundhouses at Skipton in Yorkshire where the only evidence comprised a depression at one point on the outer circumference of each house (*pers.comm. A.Aberg*).

The Balksbury House

Excavations at Balksbury, Hampshire (*Wainwright and Davies 1995*) revealed a post-built roundhouse 9.10 m in diameter with the post-holes at intervals of 1.90 m around the circumference and an extended porch or entrance on the eastern side some 2.00 m long. A reconstruction was attempted because the wall posts indicated a different building technique to interwoven basketry. On this occasion a wall plate was set on top of the posts with mortice and tenon joints to create the base cylinder. The spaces were filled in with wattle hurdling which was by definition non-structural simply serving as a base for the daub. The roof structure conjectured included an integrated porch. In the building of a cone shaped roof, as indeed in any angled roof, the timbers require to be stressed a third the way down the slant height of the roof from the apex. In practice the stress point serves to hold the roof apart counteracting the natural sag of timber along the length. In this structure coincidentally the measurement from the apex to the wall at a 45 angle exactly equalled the measurement from the stress point to the outer lintel of the porch. The angle generated at this point was a little below 40° and was judged at the time to be worth risking, or alternatively, testing. The completed structure was extremely elegant with sweeping curves in the thatch and an impressive porch. It proved extremely strong but, in fact, was doomed to destruction. The roof over the porch, below the critical functional angle, gradually began to leak, the reed becoming saturated and steadily increasing in weight. Within the space of three years the porch roof was horizontal, the rest of the cone being dragged down uncompromisingly. The house was dismantled as a failure. The failure was generated simply by disobeying a structural law. In the event it has been hypothesised that the original excavation revealed only part of the building plan of this structure, that being the inner ring of posts. All evidence of the outer wall had disappeared (*Guilbert 1981*), the original plan being similar to the Pimperne House (q.v. below).

■ **Fig. 2** The finished Balkesbury house (photo Reynolds).

■ **Fig. 3** The framework of the Balkesbury house. Unlike the Maiden Castle house, its strength is drawn from the continuous wall plate attached to the uprights with simple mortice and tenon joints (in: Reynolds 1979, 94).

The Conderton House

Excavations at Conderton Camp on Bredon Hill, Worcestershire (*Thomas 2005*) revealed the foundations of a stone-built roundhouse. The structure survived as two courses of dry stone footings of an Iron Age house with a paved porch. The internal diameter was 6.09 m, the external diameter 7.91 m, the walls averaging 0.91 m thick. The doorway was quite narrow at just 0.90 m in contrast to the great majority of timber houses. There was evidence of a collapse of some 2.80 m of the wall around the circumference in the north-east quadrant. During the excavation, an experiment was carried out to attempt to establish the original wall height. Stone collapse was carefully gathered from a segment of the excavated area centring on the middle of the house and extending to the limits of the excavation. All the remnant stone rubble was gathered and rebuilt onto the section of wall contained within the segment. The resultant height of the wall was about 0.80 m. This trial begs a number of questions, not least of which is the potential re-utilisation of fallen stone in local field walls, which are a common feature of the field boundaries on the hill. It is likely that any collapse material would have been thoroughly overgrown had it been left in situ originally, forming a mound of which a large number remain to this day and to which was ascribed local suspicious tradition (*Reynolds and Lloyd 1967*). More importantly, the kind of stone used in both the house and the field walls of two millennia later can be found simply by digging into the hillside, especially on the oolitic limestone capping. The large number of quarry pits on the hill suggest that the field walls were created from freshly-quarried stone. The exercise, therefore, had considerable value and allowed one to suggest that the original wall could have been but a little higher than the trial showed.

As in any reconstruction, all the specific data as they survived were carefully replicated after detailed study. This reconstruction followed the pattern of all such exercises, in that the major benefit to accrue emerged from those very aspects which were assumed to be simple, yet when faced with the physical problem, proved the most difficult to solve. The original walls were built of the loose upper layers of limestone, the general size being small. It would appear that the wall was built with two faces and then infilled with rubble. This, while commonly suggested as a method of building, is an illusion. The advice of a local stonemason, Mr. Hopkins of Tewkesbury, was sought, who, after some persuasion, taught the author the rudiments of building dry stone walls. This examination of the evidence rather disabused the lay conjecture that one simply built up two face walls and then filled the interior with rubble. In practical terms such a wall would be inherently unstable and would readily collapse if any pressure were exerted on it, especially any lateral thrust such as one would expect from a roof.

The original wall was in reality carefully laid throughout. The edging stones were laid first, usually two courses at a time. The interior was then laid so as to lock in as many of the edging stones as possible. The whole exercise is like a heavyweight interlocking jigsaw puzzle. The mason was quite adamant that ‚rubble-filled walls' was an extremely poor description misunderstood by the general public, in that the degree of skill required and the nature of the construction was not far removed from the seemingly superior solid stone wall. Simple lessons and adages were passed on to the author and need to be repeated here. *‚No one stone is handled twice - there is always a perfect place for it in the section of wall within reach of the builder'. ‚One stone never sits upon one stone'. ‚Locking stones should be used as frequently as possible'.* A brief apprenticeship gave some facility to the author and these adages were found to be fundamental.

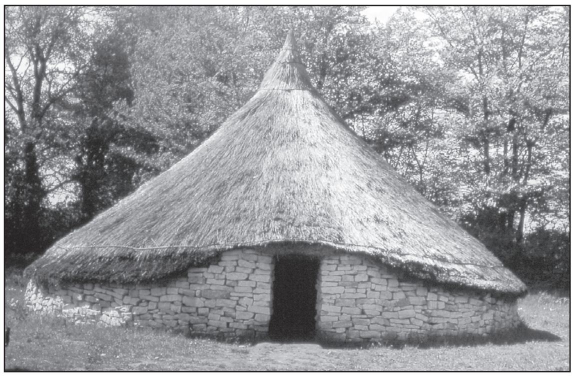
The structure was built at the Avoncroft Museum of Buildings near Bromsgrove in Worcestershire. The construction of the stone wall was, in a sense, the easiest element. It required no less than 50 tonnes of limestone and was built up to accommodate a doorway just 1.30 m high.

The major difficulties began when the alliance of disparate materials had to be forged. It was appreciated that the roof would exert considerable lateral thrust on a dry stone wall, which is generally regarded as unstable in such conditions. Indeed, the original showed clear evidence of a collapse. Mathematically the lateral pressure exerted on a point of moment is least .at 45° and most at 22.5° and 67.5°, but nonetheless there is still pressure. A series of trials was carried out to seek the best system of sustaining that pressure. The obvious method was to spread the load along a length of wall rather than allowing a pressure focus on the area of the butt of a rafter – some 0.02 m^2. This obvious point was recognised after the first tripod of rafters caused three points of wall collapse. Thereafter a series of trials was carried out with baulks of timber of differing lengths being forced against the top of the wall with pressure being exerted at 45°. The motive force employed was a Land Rover. The objective was to replicate the 2.80 m wall collapse of the original excavation. This was achieved with a baulk length of 2.40 m set just 0.30 m from the inside face of the wall. This trial was repeated only three times instead of the more usual five because of the wall rebuilding each trial involved. Twelve trials were executed to achieve this answer. Given the circumference of the structure at this position on the wall (21.0 m), the length of 2.40 m neatly allowed eight baulks with a gap left for the lintel over the doorway. The ends of the baulks either side of the doorway were built into the wall as it increased in height to accommodate the doorway.

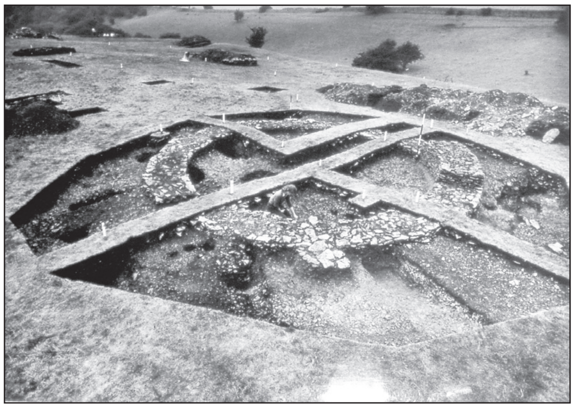
By placing the baulks of timber at this position on the wall, achieved by simple trial and error, the pressure line from the roof passes more or less diagonally through the wall mass, allowing the outer element to act as a simple weight buttress. Similarly, the trials focused attention on the details of the excavated data and of their value in interpretation allied to empirical trials. The baulks themselves were connected with simple half-lap joints. No attempt was made to fasten the timbers together since this would have precluded the possibility of the observed wall collapse.

The rafters, on the other hand, were jointed to the horizontal baulks of timber which effectively formed a wall plate. Again the joinery was as simple as possible. A prepared face was cut into the wall plate at approximately 1.50 m intervals, with the angle of this face at 45° to the horizontal. The butt of each rafter was similarly prepared by a half lap joint at right angles to the line of the wood thus allowing the face to lock by weight alone onto the wall plate. The rafters were erected in a precise sequence. Initially a tripod was set in place, with a further three rafters set into the crosstrees afforded by the tripod. A tripod was utilised because it is the simplest stable structure. Once six rafters were in place the apex of the roof was effectively full of timber, and a ring beam was inserted to support the eight subsidiary rafters. This ring beam, of willow withies bound together to form a circle around the six principal rafters, was set one third of the way down the slant height of the roof from the apex, as in the Pimperne House, to stress the rafters outwards.

When all the rafters were in place willow withies were interwoven between them to support the thatch. The next problem to emerge again concerned the wall. Trials had shown that the thickness of the wall was necessary to buttress the weight thrust of the roof, and that the wall plate needed to be positioned no more than 0.30 m from the inner circumference. This left a flat surface c. 0.5 m wide which had to be protected from the weather. Limestone is especially friable when subjected to frost action in the horizontal mode.



■ **Fig. 4** Conderton House completed (in: Reynolds 1982, 195).



■ **Fig. 5** Conderton House as exposed by excavation (in: Reynolds 1982, 191).

Various means of overcoming this problem were considered, especially since the normal system of thatching includes flying rafters to bridge this gap. Finally the obvious conclusion was reached from another contemporary experiment examining the crop yield of Emmer wheat (*Tr. dicoccum*). One element of this experiment was to assess the relative stand heights of Emmer against the modern hybrid varieties. An average of just over 1.10 m was recorded from the crop of 1970 after the ears or spikes had been harvested. When bundles of this straw had been laid flat on top of the wall an appreciable eave was created which adequately protected the wall from frost action.

The system of thatching employed was to cover the roof structure with a thick layer of hay which meshed into the interwoven willow withies and formed a support into which the straw thatch could be pegged. Over a tonne of hay and two tones of straw were used. The total dry weight of the roof was in excess of 5.5 tonnes. Thus a roof with a free span of over 6.0 m and weighing almost 6 tonnes was supported by a dry stone wall.

Unfortunately long-term study of this structure was denied because the area was subsequently required for other purposes. The three years it stood nonetheless yielded some valuable observations although the greatest information came from the building process. The erosion at the threshold referred to above (Maiden Castle house) occurred quite quickly and clearly explained the paving recovered in the excavation. Similarly the reverse to the expected drip gully occurred with a humic build-up quickly taking place at the base of the stone wall.

Stake Houses

The author has reconstructed four stake houses from respectively Breiddin Hill Fort in Wales (*Musson 1970*), Moel y Gaer, Wales (*Brassil,Guilbert, Livens, stead and Bevan-Evans 1982*) and Danebury, Hampshire (*Cunliffe 1984*). Towards the end of the Iron Age post-built houses generally gave way to houses built of closely set stakes. The usual evidence comprises a circular plan of stake holes set some 0.45 m apart with two large post-holes defining the doorway.

The reconstruction programme for the houses set out initially to discover whether such slight timbers could, in fact, sustain the weight of a roof and subsequently what was the greatest diameter such a house could safely reach. The programme developed further to investigate function and function traces.

The Breiddin Roundhouse provided evidence for the stakes to be approximately 75 mm to 80 mm in diameter initially, set 0.45 m apart into a shallow trench with the interwoven willow wands commencing at the base of the trench. As stated above the basketry walls are extremely powerful and by the nature of the interweaving the opposing tension gives great rigidity. This structure with a diameter of 5.50 m proved perfectly adequate and although it was not completed with daub or thatch, the roof was able to sustain considerably greater weight at 500 kilos per square metre than would have been exerted by a thatched roof at 50 kilos per square metre. Unfortunately this structure shared the same fate as the Conderton House described above.

The Moel y Gaer houses on the other hand have been the subject of long-term study. With virtually the same base evidence as the Breiddin Roundhouse two houses have been built. The first with a diameter of 5.40 m was completed and subsequently used for over wintering livestock, particularly cattle and sheep, the object was twofold. First to test the structure as an agricultural building and second to establish whether there was a build-up of trace evidence of function by phosphate enhancement. A strategy of five years without refurbishment was decided upon with analysis of the structure to take place at this juncture. Analysis of phosphate concentration was set for two, four, eight and sixteen years respectively. The structural analysis after five years showed the building to be sound but in need of repair. Cattle proved the most destructive on two counts. Most important they preferred to eat the straw from the thatched roof despite having ad lib hay to eat. This habit necessitated difficult repair work to the thatch and a protective inner roof skin of hurdles to be inserted. The second habit developed by the cattle was the rubbing of their horns on the daub inside walls, a habit which denuded the wickerwork of daub over fifty percent of the wall area. After five years this structure required complete refurbishment, although the structure itself was perfectly strong. Phosphate enhancement was identifiable but as yet the enhancement was minimal.

The second Moel y Gaer structure at 7.50 m diameter was the largest stake-built house recovered in the excavation. This was constructed only in the timber state without any cladding whatsoever. The objective was to assess how long the timber would remain viable when totally unprotected. In the event the timber became brittle and useless after only four years.

The last stake house examined was based upon the excavations at Danebury Hill Fort (*Cunliffe 1984*). The specific structure chosen was CS 20. The stakes were demonstrated to be 30 - 40 mm in diameter and spaced at intervals averaging 150 mm. The building had a diameter of 8.00 m with a doorway 2.00 m wide marked by post-holes and it was claimed to be a hut or house. The evidence was faithfully repeated in three dimensions and despite more than a dozen attempts proved impos-

■ **Fig. 8** The completed Pimperne house: the focal point of the Demonstration Area, this structutre is the largest reconstruction of a prehistoric roundhouse ever undertaken anywhere (photo Reynolds).

sible to roof let alone apply thatch. In all probability it was a compound, completely unroofed and may well have been used for some animal husbandry purpose. In reality the stakes were simply too slight to sustain the lateral weight thrust of a roof.

This last example underlines the value of the empirical approach in that it determines the possible and the impossible. Without such testing misinterpretation can become established and subsequently almost impossible to challenge.

The Pimperne House

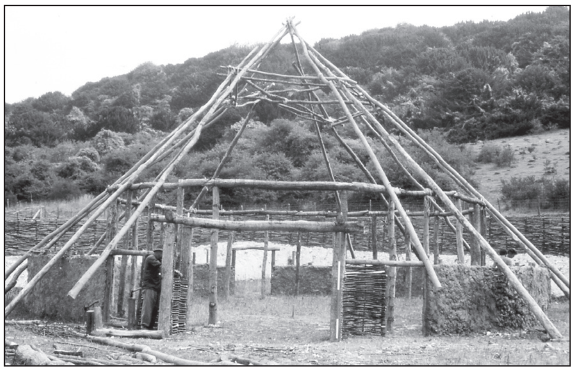
This is, without doubt, the largest roundhouse reconstruction undertaken by the author. The detailed analysis of its reconstruction has been published (*Reynolds 1982*) with both the excavation report and building study in preparation (*Harding, Blake and Reynolds 1993*). It is based upon a limited excavation of a house plan at Pimperne Down in Dorset. The plan and photograph of the excavated area provide the primary data. In effect two houses were built utilising the same porch post-holes for each structure. The outer wall comprised a perimeter of stake-holes containing an inner ring of post-holes. The distance between post-hole ring and stake-hole perimeter was just 1.50 m. At a distance of 1.50 m beyond the perimeter of stake-holes were a number of curved scoops around the circumference of the building. Internally there was evidence for a hearth and a cooking oven as well as a background scatter of post-holes which seemed to have no structural purpose.

The object of the reconstruction was to build a roundhouse based upon one of the plans in order to examine the architectural and material requirements of such a large structure and thereafter to study the life of the building for as long as possible. The construction was completed in July 1977 and has continued to yield valuable information since that time. Indeed, it is largely based upon the observations of this building that the learning curve (q.v. below) is primarily formed.

The construction yielded valuable interpretative evidence in allowing differentiation to be made between structural and constructional evidence from the excavation itself. The greatest difficulty experienced in the structure was building the roof. In all previous reconstructions of roundhouses the first phase of building the roof was the erection of a tripod of rafters which were physically lifted into place on the walls. With the scale of this building the individual rafters weighed over 170 kilos each and consequently had to be raised one at a time. The curved scoops referred to above instead of being rather anomalous features suddenly became critically important. In fact, their location, 1.50 m from the wall, with the required roof pitch of 45°, allowed the height of the wall to be identified at 1.50 m and the height of the inner ring at 3.00 m. Their distribution similarly argued for only six principal rafters and consequently an hexagonal ring beam a third the way down the slant height of the roof. This had to be the case since all the other rafters were free of the ground and given their weight had to be firmly supported at wall and inner ring and at ring beam height to prevent natural sag. The roundhouse definition of a cone set upon a cylinder further served to explain why these features were curved scoops. During the erection of the main rafters and attachment of the ring beam, the cone of the roof became out of position. By manoeuvring each of the butts of the main rafters the cone was recentralised. Final analysis showed remarkable correlation between the reconstruction evidence and the original archaeological evidence of these curved scoops.

The completed structure is quite remarkable, if only in terms of sheer scale and material requirements. Over two hundred trees were needed to build the structure, ten tonnes of daub to plaster the walls and five tonnes of thatch to clad the roof. The information yield at construction was high.

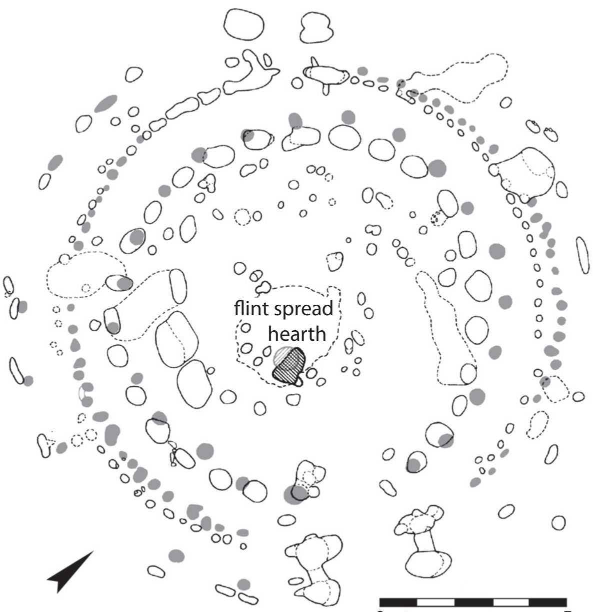
However, subsequent observations have proved even more interesting. After eight years the porch posts, the only ones exposed to the weather, required replacement. The posts had virtually rotted through at the interface between ground surface and air. In all the excavated plans of houses of this scale these porch post-holes show considerable disturbance, a disturbance which can now be explained as regular post replacement. These apart, there is no reason why the life expectancy of such houses should not run into hundreds of years rather than decades.

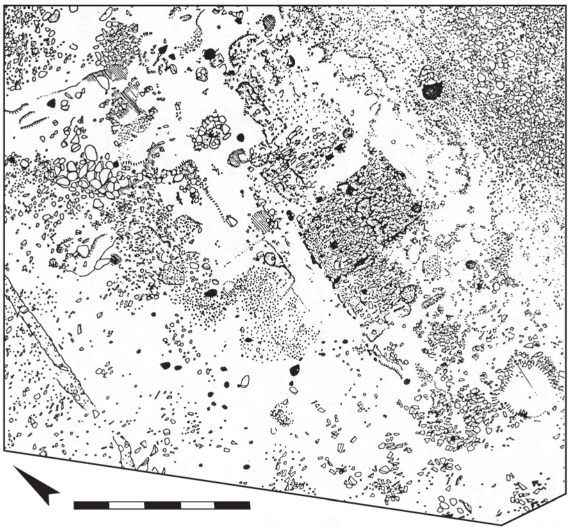


■ **Fig. 7** The Pimperne house: the six principal rafters in position (in: Reynolds 1982, 184).

Similarly the six principal rafters, so critical in the preliminary stages of roof construction, have now rotted at the ground interface. In fact, once the building was completed in 1977, the ground was dug away from the butts of these rafters in order to determine if they were still load-bearing. The fact that they weren't, further substantiates the claim of distinction between constructional and structural evidence. The butts of these rafters were left as they were to test their longevity in an exposed position. Like the porch posts they were badly rotted after a mere eight years but only below the limit of the eaves of the building.

■ **Fig. 6** Plan of the excavated site at Pimperne Down, Dorset. The postholes used in the reconstruction are shown in heavier outline. (in: Reynolds 1979, 96).



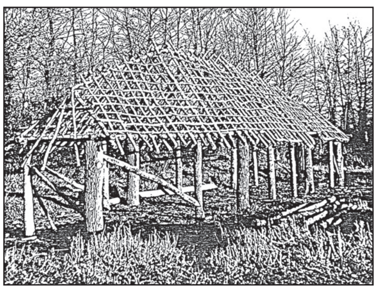


■ **Fig. 10** Wroxeter. Site 68, Phase Z (in: Barker 1977).

The house forms the major focus of the museum area of the Ancient Farm and has been used as an educational tool from its creation. Despite the passage of tens of thousands of feet, wear is minimal. Similarly the central hearth has been used regularly as well as the reconstructed clay cooking oven. To date some ten years later there is minimal sooting in the roof and all the timbers are firm and stable.

Throughout the experimentation with roundhouses the effect of a centrally placed hearth has been tested exhaustively. The simple conclusion is that there need not be chimney provision of any kind. Should there be a hole in the roof the house immediately becomes an elementary blast furnace. Sparks would be raised from the hearth into the thatch and within hours conflagration would quickly ensue.

The testing of the interior of the house is a continuous programme with special attention to changes in the soil matrix of the floor. There is an undoubted enhancement of the magnetic susceptibility of the soil within the house brought about by the effects of the fire on one hand and on the other by the total degradation of the root fibre originally present before the house was built. The results of the trials will be published in due course (*Reynolds 1993*).



■ **Fig. 11** The framework of the Wroxeter house.

Finally after ten years the house is being coated with an additional layer of thatch. Financial restrictions when the house was built meant that the original thatch was just 100 mm thick instead of the more acceptable 300 mm. Even so the damage has been minimal, mostly occasioned by birds robbing straw for nest building and occasional storm damage. During the rethatching, inspection showed all the timbers to be firm and sound, including the hazel purlins. Once the thatch is completed the roof weight will be increased to over ten tonnes of straw dry weight.

The particular importance of this study is that it is a long-term research programme. The information yielded to date is remarkable and in future should become invaluable, especially as electronic prospection techniques continue to improve. In effect the house is a simple laboratory, the history of which is fully recorded. Its value as a source of comparative evidence can only increase with time.

Romano-British Grain driers

Reconstruction can be particularly valuable in testing the hypothesis of a function. On a large number of Romano-British sites distinctive subterranean flues have been recovered and identified as grain driers and ascribed as an agricultural innovation necessitated by the British climate on one hand and on the other by improved Roman agricultural technology. The author was approached to reconstruct two of these so-called grain driers and test their function. Two sites were used, one from Foxhole Farm in Hertfordshire (*Partridge 1976*), the other from Barton Court Farm in Oxfordshire (*Miles 1984*). The reconstructions replicated the evidence from the two sites, with logical extension to include a necessary superstructure (*Reynolds and Langley 1979*). Subsequent testing proved incontrovertibly that they were not grain driers and were in all probability malting floors. Or at least the malting floor hypothesis was validated by experiment, whereas the grain drying capability was totally disproved.

In this case the learning curve is steep at the construction and immediate testing phase. Subsequent observation has shown that the building itself while perfectly adequate for the trials was found to be incomplete in the sense that erosion occurred in the stoke hole area, while none was present in the original.

The Wroxeter House

Wroxeter Site 68 Phase Z (*Barker 1973*). This particular reconstruction is based upon the excavations of Building I of the Baths Basilica at Wroxeter, the site of the Roman town of Viriconium in Shropshire. The building was revealed when the plough soil was removed and the uppermost archaeological layers were cleared simply by removing the humic soil and leaving all stones, tile, clay and pottery in situ. The maximum depth of the post sockets was 20-30 mm so that it was clear that none of the posts had been sunk into the ground and that they could not therefore have stood independently. The nature of the evidence argued that the site had not been damaged by plough action at all and that the building was the last structure on this part of the site before abandonment.

The object of the reconstruction was to test the hypothesis that the evidence could actually sustain a structure. To that end the archaeology was faithfully replicated, the end product being a bow-sided hog—backed building asymmetric about the central latitudinal axis. The evidence indicated a framed building but without sill beams, the walls being presumed to be wattle and daub. The end product fully justified the interpretation and, therefore, the reconstruction. However, the life of the building itself was chequered. The first phase, where the wall comprised the uprights bearing the roof of A frames locked into position by the purlins and braced by the hipped gables, suffered the indignity of being blown down along its length like a house of cards. It was successfully re-erected and thereafter cross-braced diagonally across each bay. The result of the construction, therefore, amplified the above-ground interpretation of the structure. As with the Conderton and Breiddin houses, the structure was not studied beyond the initial stage of timber construction.

Reconstructions - postscript

There has been little or no reference to the vexed problem of solitary post-holes, pairs of post-holes, four-post structures, lines of post- and stake holes. All of these patterns, if they form patterns in the opinion of the excavator, should be the subject of empirical investigation. However, with such structures there is a critical need for any reconstruction to be closely allied to function and, therefore, potential function traces which may on the one hand confirm the interpretation with the available data or alternatively provide comparative evidence which is yet to be recognised and isolated in the archaeology.

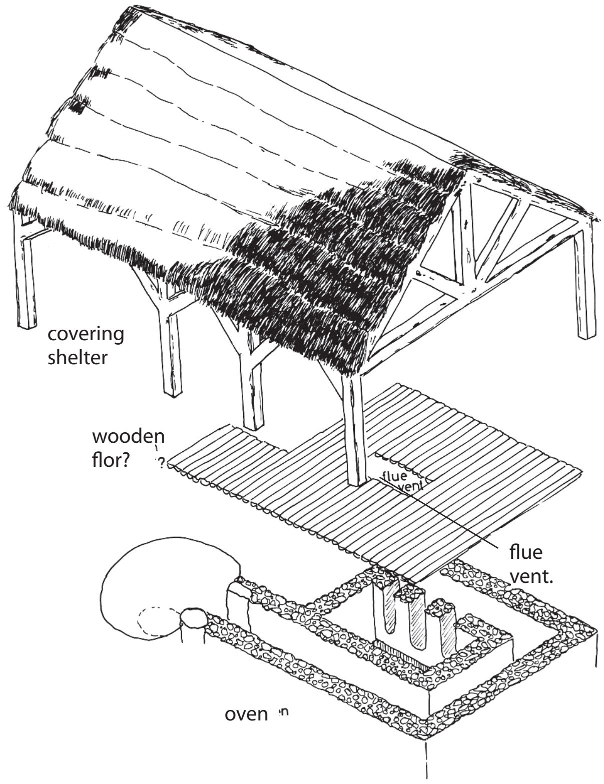
One particular example, currently the subject of a research programme, is the explanation of the ubiquitous two-post structure. There are a considerable number of possible explanations but given the requirement above of confirmatory evidence the hypothesis raised is that a pair of post-holes may well argue for the presence of a leaf fodder drying rack and imply leaf fodder as a complement or alternative to hay. The confirmatory evidence sought is the waste product of leaf foddering, the inedible twigs. In effect the evidence has to be in carbonised form and one is seeking an analysis of all carbonised twig sections down to species. Given a persuasively high percentage of elm (*Ulmus sp.*) and ash (*Fraxinus sp.*) against other species, the hypothesis would gain validity.

The purpose, as with all reconstructions, is to enhance our understanding of the archaeological data but in this respect the danger of isolated as opposed to integrated reconstruction is underlined. Since the purpose of archaeology is to understand man in the landscape, the study of a structure is essentially limited the study of a structure within a context, whether that context comprises process or function or product, has to be more valuable.

It is in this area of more ephemeral structures, structures which respond to a functional or economic need, that the implicit difficulty of reconstruction is emphasised and where it must always be stressed that validity is the highest objective, actual prehistoric truth is always beyond reach.

In all of the above cases the objective has been to present the knowledge gained from the process of reconstruction and analysis of function. Full publication of all these structures in a ‚corpus' is forthcoming wherein all details will be made available. At this point it is perhaps worth reiterating the nature of the ‚learning curve'. Most information, though not necessarily the most valuable information, is achieved in the construction and immediate post-construction phase. Critically, there are secondary and tertiary peaks which occur when the structure reaches a stage when repair or refurbishment becomes necessary. The experience of the above suggests that these peaks occur after eight to ten and twenty years from construction. Thus given the remit of the programme, there are clear cut-off points. The original building will yield a dramatic return and may represent a completed phase. However, particularly from the Maiden Castle House and the Pimperne House, long-term study and observation bring more significant and telling results from the secondary peak. Similarly where function is the subject of analysis, particularly in terms of mutation of soil nature whether in phosphate concentration or magnetic susceptibility enhancement, the long-term approach is the only viable one where the return is steadily reinforced through time.

On consideration of the original purposes of European building in prehistory and Protohistory, all the evidence points to buildings lasting many decades. They are hardly temporary huts and sheds. There is, therefore, a danger in accepting the principles of the learning curve/information return and accepting the maximum return in the shortest elapse of time. There is a perfectly understandable desire to maintain a reconstruction in a primitive state in the mistaken view that this is what it would have looked like.



■ Fig. 9 Foxholes farm - exploded view of a suggested reconstruction of a corndryer 5 (in: Partridge 1989).

Indeed, pressure is often brought to bear by interested but uninformed bodies to maintain the newness because it is more impressive. Such views need to be challenged on the grounds of the further critical information to be gained through time. In museological and educational terms it is simple to justify since the primary purpose is to present the normal rather than the abnormal.

In conclusion there seems little point in building a reconstruction unless there is a specific question or questions which require answers. The motivation for reconstruction, however, need not be limited to this particular role since there are undeniable benefits from subsequently using resultant structures in museological and educational fields. However, to build only for those latter options is to deny the opportunity for scientific investigation with its advantages in elucidating the potential of the archaeological evidence. Indeed, given the cost of reconstruction, both in terms of financial and labour investment, it is profligate to ignore the scientific basis of reconstruction. The rewards in terms of knowledge on one hand and on the other the integrity of presentation and therefore education far outweights the extra commitment required in planning and execution.

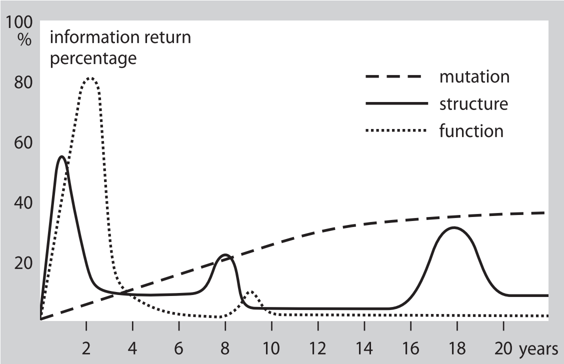


Fig. 12 Information return / learning curve.

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Summary

Zur wissenschaftlichen Basis für die Rekonstruktion ur- und frühgeschichtlicher Häuser

Es gibt eine Dichotomie der Motivation für die Anlage von Hausrekonstruktionen. Auf der einen Seite gibt es den Forschungsansatz, der Fragen nach den Materialressourcen, nach ihrem Management, nach den statischen Notwendigkeiten der Konstruktion, nach den paläoökologischen Rahmenbedingungen, nach der funktionellen Analyse, nach dem strukturell bedingten Verfall im Laufe der Zeit und nach der physischen Interpretation der archäologischen Befunde stellt. Auf der anderen Seite gibt es die pädagogische Motivation, die sowohl museale als auch erlebnisorientierte Elemente beinhalten muss.

Die Forschungsrichtung enthält eindeutig einen primär pädagogisch-museologisch orientierten Fokus, bei dem die dreidimensionale Struktur als eine Art der Demonstration zu verstehen ist, die in vielfältiger Weise genutzt werden kann. Der kritische Punkt ist dabei, hier Problembereiche mit Blick auf die Festlegung von Grenzen zu benennen, innerhalb derer die Rekonstruktion von pädagogischem bzw. von Forschungswert ist und dabei Standards festzulegen, die als Leitlinien gelten können. Die Absicht der Abhandlung ist es, auf der Basis von Fallbeispielen der Hausrekonstruktionen von Maiden Castle (Dorset), Balksbury (Hampshire), Conderton Camp (Bredon Hill, Worcestershire), Pimperne Down (Dorset) und anderen Orten, die wissenschaftliche Basis für eine Rekonstruktion herauszuarbeiten und zu versuchen, die verschiedenen, zum Themenkomplex gehörenden Fragestellungen voneinander abzugrenzen.

Fond scientifique des reconstitutions de maisons préhistoriques et protohistoriques

Les motivations pour les reconstitutions sont doubles. D'abord, il s'agit de la recherche, y compris les questions des ressources de matières et de leur gestion, des aspects de construction, de l'environnement, de l'analyse fonctionnelle, de la dégradation structurale en fonction du temps et, du point de vue critique, les questions de l'interprétation physique des découvertes archéologiques. De l'autre côté, il y a l'éducation qui doit impliquer des éléments de musée ainsi que ceux plus récréatifs. La recherche implique sûrement un potentiel considérable éducatif et muséologique, puisqu'une structure à trois dimensions constitue un échantillon démonstratif qui se prête à être utilisé de plusieurs manières. Le point critique, c'est la définition des problèmes de reconstitution pour pouvoir délimiter un cadre où les reconstitutions assument une valeur scientifique/éducative ainsi qu'une série de standards qui puisse servir de guide. Cette conférence a pour objectif d'examiner le fond scientifique des reconstitutions et de formuler une définition du rayon pertinent de questions, tout en s'appuyant sur des exemples de reconstitutions de Maiden Castle (Dorset), Balksbury (Hampshire), Conderton Camp (Bredon Hill, Worcestershire), Pimperne Down (Dorset) et d'autres.